An *in vitro* comparison of the bleaching efficacy of 35% carbamide peroxide with established intracoronal bleaching agents

M. Y. Lim[1], S. O. Y. Lum[1], R. S. C. Poh[1], G. P. Lee[1] & K.-C. Lim[2]

[1]Faculty of Dentistry; and [2]Department of Restorative Dentistry, National University of Singapore, Singapore

Abstract

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Aim To evaluate the bleaching efficacy of 35% carbamide peroxide, 35% hydrogen peroxide and sodium perborate for intracoronal bleaching of root filled discoloured teeth.

Methodology Extracted premolars were artificially stained using whole blood then root canal treatment was performed. After obturation, a 2 mm intermediate base was placed 1 mm below the buccal amelocemental junction. Intracoronal bleaching was performed in 11 teeth per group, using either 35% carbamide peroxide gel (group CP), 35% hydrogen peroxide gel (group HP) or sodium perborate mixed with distilled water (group SP). The bleaching agents were replaced after 7 days. The shade of the teeth was evaluated at day 0, 7 and 14. The results were analysed using Kruskal–Wallis one-way analysis of variance and Mann–Whitney *U*-test.

Results At the end of 7 days, both groups CP and HP lightened by 8 ± 3 Vita tab positions, respectively, whereas group SP lightened by 5 ± 3 tab positions ($P < 0.05$). At the end of the second bleaching period at day 14, group CP and HP lightened by a further 2 ± 2 and 2 ± 3 tab positions, respectively, whereas group SP lightened by a further 3 ± 4 tab positions. There were no statistical differences between groups at day 14.

Conclusions Thirty-five per cent carbamide peroxide and 35% hydrogen peroxide were equally effective for intracoronal bleaching, and significantly better than sodium perborate after 7 days. After 14 days, there were no significant differences between the groups. Thirty-five per cent carbamide peroxide can be recommended as an equally effective alternative to hydrogen peroxide for intracoronal bleaching.

Keywords: carbamide peroxide, drug effects, hydrogen peroxide, sodium perborate, tooth bleaching, tooth discolouration.

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Introduction

Intracoronal bleaching is an established, simple, cost-effective and conservative method of improving the colour of discoloured teeth that have received root canal treatment, in the appropriate circumstances.

Correspondence: Dr Kian-Chong Lim, Department of Restorative Dentistry, Faculty of Dentistry, National University of Singapore, 5 Lower Kent Ridge Road, Singapore 119074 (Tel.: (65) 67724954; fax: (65) 67732603; e-mail: dentalcare@pacific.net.sg).

The most commonly used bleaching agents used to produce the desired aesthetic colour change are hydrogen peroxide and sodium perborate, either used alone or in combination. More recently 10% carbamide peroxide has also been recommended (Vachon *et al.* 1998). One of the undesirable consequences of intracoronal bleaching is external cervical root resorption. This has been attributed to excessive hydrogen peroxide diffusing into the periradicular tissues, possibly through cemental defects (Rotstein *et al.* 1991), although the exact mechanism has not been determined. Though the incidence of cervical external cervical root resorption associated with intracoronal bleaching is low

(MacIsaac & Hoen 1994, Baratieri *et al.* 1995), some authors recommend that it is safer to avoid hydrogen peroxide for intracoronal bleaching (Cvek & Lindvall 1985, Friedman *et al.* 1988, Lewinstein *et al.* 1994, Attin *et al.* 2003), and sodium perborate be used instead.

Studies on the efficacy of intracoronal bleaching agents in artificially discoloured teeth however, indicate that the most widely used alternative, sodium perborate, is inferior to 30% hydrogen peroxide used either alone or in combination with sodium perborate; consequently, further bleaching sessions will be required to achieve the desired aesthetic result. The increased number of treatment sessions will increase the cost of the treatment. The success when bleaching with 30% hydrogen peroxide varies between 80 and 93% after two bleaching sessions compared with 39–53% when using sodium perborate alone (Ho & Goerig 1989, Warren *et al.* 1990, Rotstein 1991, Rotstein *et al.* 1993). The other intracoronal bleaching alternative, 10% carbamide peroxide has been found to be less effective than a sodium perborate–30% hydrogen peroxide combination after three bleaching treatments when evaluated at 14 days (Vachon *et al.* 1998), but equally effective as sodium perborate with water as both successfully bleached 65 and 64% of the artificially discoloured teeth, respectively, after two bleaching sessions over 12 days (Perrine *et al.* 2000).

From both economic and safety reasons, it would be desirable to achieve the aesthetic change in the minimum number of treatment sessions as well as to minimize exposure of the periradicular tissue to hydrogen peroxide. It has been reported that intracoronal bleaching with 35% carbamide peroxide gel produces low levels hydrogen peroxide diffusion into the periradicular region, comparable with sodium perborate (Lee *et al.*, submitted). However, the efficacy of 35% carbamide peroxide for intracoronal bleaching has not been determined. This study evaluates the intracoronal bleaching ability of 35% carbamide peroxide relative to 35% hydrogen peroxide and sodium perborate using artificially stained extracted human teeth.

Materials and methods

Single-rooted premolars, extracted for orthodontic reasons from patients under the age of 21 years were used. A solution of 2.5% sodium hypochlorite soaked into gauze was used to remove any soft tissue covering the root surface and any calculus was removed with scalers. The teeth were then stored in thymol saline before being artificially stained with whole blood following the method described by Freccia & Peters (1982). The teeth were immersed in whole human blood without the serum, and centrifuged at 3200 rpm for 20 min twice daily over 3 days to enhance penetration of the haemolysed red blood cells into the dentinal tubules. The precipitate was removed and the teeth immersed in the remaining haemoglobin-rich haemolysate for a further 3 days, centrifuging it twice daily as previously described. The resultant discoloured teeth were then washed in distilled water.

After standard access cavity preparation, the root canals were cleaned and shaped using 2.25% sodium hypochlorite for irrigation, and size 4 Gates-Glidden drills were used to maintain the coronal root canal openings approximately the same size. The root canals were obturated with thermoplasticized gutta-percha (Obtura II; Obtura Corporation, Fenton, MO, USA) and root canal sealer (Roth sealer; Roth International Ltd, Chicago, IL, USA). Sufficient gutta-percha was removed to allow placement of a 2-mm thick intermediate base of Cavit (3M ESPE, Seefeld, Germany) to a level 1 mm apical to the labial cemento-enamel junction (CEJ). The walls of the access cavity were cleaned of any residue using a small carbide bur followed by thorough rinsing.

The prepared teeth were randomly divided into four groups of 11 specimens each, and the baseline colour evaluation performed before they were intracoronally bleached twice 7 days apart using either:

Group CP: 35% carbamide peroxide gel (Opalesence Quick, Ultradent Products, Inc., South Jordan, UT, USA).

Group HP: 35% hydrogen peroxide gel (Opalescence Endo, Ultradent Products, Inc.).

Group SP: 2 g sodium perborate (Roth International Ltd) per mL of distilled water to form a thick paste.

Group CL: Distilled water only (control).

After 0.04 mL of the bleaching agent was syringed into the access cavity of the tooth, it was sealed with Cavit. After 7 days, the colour of the bleached teeth was determined. The original bleaching agent was then washed out with water and a fresh portion of bleaching agent syringed into the access cavity as described previously. The teeth were left for another 7 days before the next colour evaluation was performed at 14 days. The teeth were wrapped in gauze soaked with distilled water and kept in an incubator at 37 °C throughout the experiment.

The colour of each tooth was evaluated using the Vita Lumin shade guide (VITA Zahnfabrik, Bad Säckingen, Germany) under standardized lighting

conditions. Evaluation was performed at day 0, 7 and 14 by two examiners working independently, who were previously calibrated in the pilot study. Only when there was no agreement between the two evaluators, was a tooth re-evaluated by both to come to a common decision. The shade guide was ordered by value order from lightest to darkest as determined by the manufacturer, and a corresponding position number assigned (Table 1) to allow statistical analysis. Data was analysed using Kruskal–Wallis one-way analysis of variance and Mann–Whitney *U*-test.

Results

There was 53% inter-evaluator agreement in colour evaluation between the two evaluators.

A summary of the baseline (day 0) tab position of the discoloured teeth and the changes in tab position after one intracoronal bleaching treatment evaluated at day 7 and after the second bleaching treatment evaluated at day 14 is shown in Table 2 and graphically illustrated in Fig. 1. There was no colour change noted in any of the sample group CL.

There was no statistical difference in the distribution of discoloured teeth between the three groups at baseline ($\chi^2 = 2.044$, d.f. $= 2$, $P = 0.360$). At day 7 there was a statistical difference between groups ($\chi^2 = 7.414$, d.f. $= 2$, $P = 0.025$). Although there was no statistical difference between groups HP and CP ($P > 0.5$) both these groups were statistically superior to group SP ($P < 0.05$). At day 14, there were no statistical differences between all groups ($\chi^2 = 0.374$, d.f. $= 2$, $P = 0.830$).

Table 2 shows the mean tab position change for all 11 samples per group. However, taking only those teeth which showed further colour change after the second bleaching treatment (day 14), the mean colour change for these teeth at day 14 was 3, 4 and 6 tabs lighter for groups CP, HP and SP, respectively.

Discussion

It is well established that visual colour determination is subjective, compared with the objectivity of spectrophotometric evaluation (Horn *et al.* 1998). Vachon *et al.* (1998) utilized a spectrophotometer to monitor colour change associated with intracoronal bleaching. Based on the spectrophotometer readings at the completion of intracoronal bleaching, all the teeth were still statistically significantly darker than they were before being artificially discoloured, implying the bleaching agents evaluated were unsuccessful. However, clinical experience and visual evaluation in other studies have shown intracoronal bleaching is capable of restoring teeth to their original colour or even lighter. Therefore, Vachon *et al.* (1998) suggested that although their spectrophotometer readings may indicate a statistical difference, these differences could be clinically indistinguishable to the human eye. Some studies to evaluate the effectiveness of external tooth bleaching agents have also used both spectrophotometer and visual evaluation of colour change using the Vita Lumin shade guide (Nathoo *et al.* 2001, Li *et al.* 2003). Results from these studies using both methods of evaluation were consistent. Therefore, in this study, only human visual evaluation of colour change was used, as only relative colour changes were of interest. Furthermore, the results will be more meaningful to both the clinician and the patient, and the clinician will be able to relate to the results of this study. The results

Table 1 Vita lumen shade tabs arranged in order of increasing value and the position value ascribed

Vita tab	B1	A1	B2	D2	A2	C1	C2	D4	A3	D3	B3	A3.5	B4	C3	A4	C5
Position	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

Table 2 Summary of baseline shade position (day 0) and position change compared with baseline after one bleaching session (day 7) and two bleaching sessions (day 14)

	Day 0		Day 7			Day 14		
Group	Mean	SD	Mean Δ	SD	*n* Δ	Mean Δ	SD	*n* Δ
CP	14	3	−8	3	11/11	−10	3	7/11
HP	12	3	−8	3	11/11	−10	3	5/11
SP	14	2	−5*	3	10/11	−8	4	5/11

n Δ, number of samples with shade change.
*Significant difference with other two groups: $P < 0.05$.

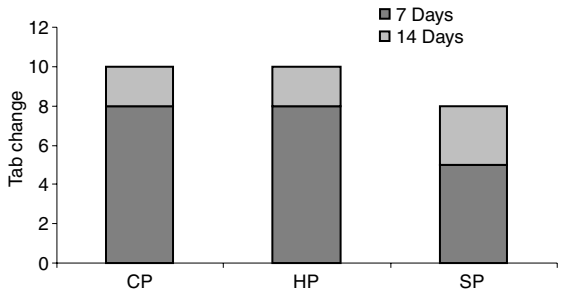

Figure 1 Graph of mean shade tab position change after one (day 7) and two (day 14) bleaching sessions produced by intracoronal bleaching with 35% carbamide peroxide gel (CP), 35% hydrogen peroxide gel (HP) and sodium perborate (SP).

could also serve as a guide to the relative colour changes that may be expected in intracoronal bleaching using the different bleaching agents.

Colour perception is very complex. Furthermore, the evaluator's experience appears to have no bearing on their colour matching ability (Horn *et al.* 1998). To minimize the subjective influences, in this study both evaluators performed colour determination independently under the same lighting conditions, and only conferred when re-examining samples when there was no initial agreement. The 53% inter-evaluator agreement in this study was within the range of 50–65% majority agreement determined by Horn *et al.* (1998). The inter-evaluator disagreements arose in situations where, as clinicians will be familiar, a tooth's colour is not always identical to a Vita colour tab, and a decision has to be made as to which of two adjacent colour tabs is closer.

Our results indicate that groups CP and HP were equally effective for intracoronal bleaching, and both groups were better than group SP after one bleaching session ($P < 0.05$). With groups CP and HP, there was a mean improvement of 8 Vita Lumin shade tabs; whereas group SP had a mean improvement of 4 Vita Lumin shade tabs. It took group SP two bleaching sessions over 14 days to lighten the teeth 8 Vita Lumin tabs that the other two groups achieved in one treatment.

In fact, approximately half of all teeth from all groups did not undergo further colour change after one treatment session. Those that did undergo further lightening after the second bleaching session did so by a mean of 3 tabs for both groups CP and HP, respectively, and 6 tabs for group SP. Therefore, intracoronal bleaching with sodium perborate could be equally effective as the other two groups, but it would take at least two bleaching sessions to achieve a similar result.

A recent literature review (Attin *et al.* 2003) recommended the use of sodium perborate powder and distilled water for intracoronal bleaching, and specifically contraindicated the use of 30% hydrogen peroxide or the application of heat, which increases the risk of external cervical resorption. The present study has demonstrated that the efficacy of 35% carbamide peroxide gel is similar to 35% hydrogen peroxide gel, and superior to sodium perborate and water for intracoronal bleaching of artificially stained teeth. In an evaluation of the diffusion of hydrogen peroxide through the discoloured, root filled tooth undergoing intracoronal bleaching, Lee *et al.* (submitted) determined that there was no significant difference in hydrogen peroxide detected in the periradicular area when using either 35% carbamide peroxide gel or sodium perborate with distilled water. A statistically significantly greater amount of hydrogen peroxide diffused out using 35% hydrogen peroxide gel. Therefore, 35% carbamide peroxide gel could be used as the intracoronal bleaching agent of choice as it appears to be equally safe as sodium perborate but with the efficacy of 35% hydrogen peroxide.

As 35% carbamide peroxide breaks down to the approximate equivalence of 12 % hydrogen peroxide, the results obtained were perhaps surprising, as it was expected that 35% hydrogen peroxide gel would produce a greater bleaching effect than 35% carbamide peroxide. After all, in comparisons using different concentrations of carbamide peroxide for external vital tooth bleaching, higher concentrations tend to be more effective, although after more bleaching sessions the weaker bleach will eventually produce the same lightening effect (Leonard *et al.* 1998). The equal effectiveness of 35% hydrogen peroxide and 35% carbamide peroxide gel could be because with 35% hydrogen peroxide there is an excess of active ingredient, which simply just diffuses unreacted through the root tissue. Another possibility is that carbamide peroxide penetrates dentine less readily than hydrogen peroxide (Cooper *et al.* 1992), thus it may remain within dentine where it can effectively break down the chromogens more efficiently as opposed to hydrogen peroxide that penetrates dentine more readily. Another contributing factor to the greater efficacy of carbamide peroxide relates to the relationship between pH and rate of reaction of the bleaching reaction; as the higher the pH, the more free radicals are available for bleaching. Optimal ionization occurs when hydrogen peroxide is buffered in the range of pH 9.5–10.8. In this range, the bleaching effect could be 50% better than

when it is more acidic (Sun 2000). Since 35% hydrogen peroxide gel is pH 3.7 and 35% carbamide peroxide gel is pH 6.5 (Price *et al.* 2000), carbamide peroxide gel may have approximately the equivalent quantity of free radicals as 35% hydrogen peroxide gel available for bleaching.

In an analysis of all reported cases of external cervical resorption associated with intracoronal bleaching, the common trend in all the affected cases was the absence of a seal over the root filling (MacIsaac & Hoen 1994, Baratieri *et al.* 1995). It would therefore, be prudent that the root filling is sealed off from the bleaching agent with an intermediate base, no matter which intracoronal bleaching agent is selected for use. A 2 mm layer of Cavit or Coltosol has been shown provide an effective seal (Hosoya *et al.* 2000).

This study has demonstrated that 35% carbamide peroxide is equally effective as 35% hydrogen peroxide when the tooth has been artificially discoloured with chromogens from the breakdown of blood products. However, discolouration associated with root canal treatment may also arise from protein degradation of the dental pulp (Hattab *et al.* 1999) and discolouration from root canal cements (van der Burgt & Plasschaert 1986). Whether 35% carbamide peroxide is equally effective against these chromogens requires further investigation.

Conclusions

Thirty-five per cent carbamide peroxide and 35% hydrogen peroxide were equally effective for intracoronal bleaching, and significantly better than sodium perborate after one bleaching treatment for 7 days. After a second bleaching treatment for another 7 days, there were no significant differences between the groups. Thirty-five per cent carbamide peroxide gel can be recommended as an equally effective alternative to 35% hydrogen peroxide gel for intracoronal bleaching.

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